

Horticulture

extension.usu.edu

September 2018

Horticulture/Fruit/2018-04

Constructing Shade Structures: Small Area Vegetable and Fruit Production

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Introduction

Sunburn injury is one of the more common fruit disorders in Utah. Injury occurs due to high solar radiation levels and air temperatures, low relative humidity, and high elevations. Ultraviolet (UV) radiation is greater at high elevations and is the greatest contributor to damage. Sunburn injury can be reduced by natural (increased leaf coverage) or artificial (cloth screening) shade. For more information on how sunburn injury occurs, various methods of protection, and plant response to shade see USU's [Using Shade for Fruit and Vegetable Production](#) fact sheet.

Growing large healthy plants is the easiest way to create natural shade. Healthy plants have more and larger leaves which naturally shade fruits. Proper irrigation, good plant nutrition, and appropriate pest management ensures plants grow and produce good leaf coverage. However, over time, during regular harvests, or if plants are stressed, fruits can become exposed to direct sun and sunburn injury occurs. Therefore, alternative forms of shade are needed to maximize fruit production with a minimum of fruit injury.

Shade cloth has proven effective in reducing and almost eliminating sunburn damage to crops in Utah. Although using shade cloth increases production costs, marketable yields are much higher in high-value crops (colored peppers, tomato, raspberries) because losses due to sunburn are significantly reduced. This fact sheet will discuss different strategies and methods for building shade over small production areas and will provide a materials list needed to construct shade structures.

Shade structure size and shape will vary depending on the field, the crop grown, and location. These differences

make a specific construction guide difficult. Instead, this bulletin will focus on basic instructions and materials needed for constructing three (3) types of small area shade structures. These include covering individual rows, building small field horizontal shade covers, and high tunnel shading.

Individual Row Shade

Constructing shade structures over individual rows is relatively simple. An arched support is spaced uniformly down the row and the shade cloth is attached to this frame (Fig. 1). Supports can be made from conduit piping (Fig. 1), PVC, high-tensile wire, or some other



Figure 1. Shade cloth structure using conduit piping constructed over individual rows suitable material.

Electrical conduit pipe has worked well in projects at USU and an example is detailed below.

Conduit piping ($\frac{1}{2}$ inch) is bent using a 3-foot pipe bender (Fig. 1) to fit the needs of your row size. Arch supports (10-foot conduit lengths) have a base width of 3 feet, and are 4.5 feet tall at the peak which works well over a staked tomato crop (3 feet wide rows). Half-inch rebar sections (24 inches long) are spaced 10 feet apart along the row, then pounded into the soil and the conduit arch is slid over the rebar (Fig. 2). Although not entirely necessary, a washer welded 3 inches from the top of the rebar stops the conduit from being pressed into the soil. To keep the arches vertical and to help keep the shade cloth from sagging between the arches, 10-foot lengths of conduit connect the arches (Fig. 3). These spanners



Figure 2. Metal conduit piping over rebar pounded into the ground. A washer, welded onto the rebar to prevent conduit from sinking into the soil.



Figure 3. Cross-clips connecting purlin to arch on individual row shade structure.

(purlins) are joined with couplers and connected to the arches using cross clamps (Fig. 3).

On east/west oriented rows, shade cloth provides protection only to the south-facing side and top of the row, leaving the north side open for easy access the crop. For north/south oriented rows, cover the west side and top of the row. Shade cloth width will vary depending on the height of the arch. For the 4.5-foot tall arch, 6-foot wide cloth works well. Shorter arch heights and narrower widths can be constructed for short statured plants. Special knit fabrics that will not unravel when cut or need seams on the edges are useful for this type of shade structure. Shade cloth is secured to the conduit arches using plastic $\frac{1}{2}$ -inch clips (Fig. 4). Use 3 clips on each arch and 2 clips on the spanners to adequately fix the shade to the framing. For additional strength on the end arches, zip ties can be added. Shade cloth lengths should be about 10 feet longer than the row length to allow coverage on either end of the row.



Figure 4. Snap clamps re-enforced with zip-ties on end arch to hold shade cloth onto structure

Small Field Shade

Horizontal shade structures can be constructed over multiple crop rows by installing posts (T-post, treated wood, or metal) and high tensile heavy-gauge wire to support the shade cloth (Fig. 5). The example below uses 10-foot T-posts.

Measure the field area you would like to cover and plan on placing a T-post every 15 to 20 feet around the perimeter. If the area is more than 40 feet wide, install



Figure 5. Shade cloth suspended over pepper crop using T-posts and wire structure.

center posts to keep the cloth from sagging. 10-foot tall T-posts are ideal as 3 feet of the post is buried, providing good support, and the remaining 7 feet is high enough to comfortably work under. The tops of the posts should be covered (PVC endcap, fabric, heavy-duty tape) to keep sharp edges from tearing the shade cloth.

Attach high tensile wires to the posts and use a winch to tighten the wire without bending the posts. These wires help support the shade cloth. Depending on the field size, run wires to the ground at each corner and attach them to anchors for additional support (Fig. 6). The wire (14 to 10 gauge) needs to be strong enough to hold up the fabric and withstand strong wind events. If the area is bigger than 20 x 20 feet, install anti-billowing wires on the top of the shade cloth to keep it in place or zip tie the shade to the support wires. Side curtains (Fig. 5) can be added on the south and west sides if needed. These do not need to run all the way to the ground.

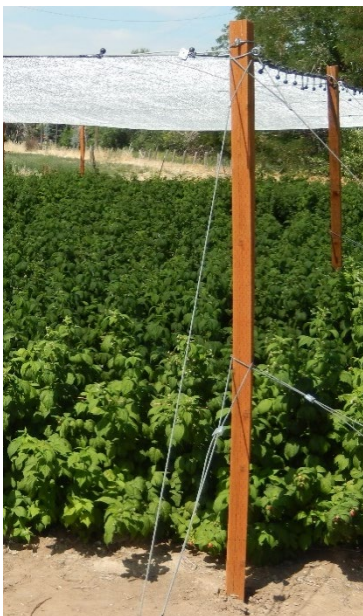


Figure 6. Wire anchors for additional support.

High Tunnel Shade

Applying shade over an existing high tunnel (Fig. 7) works well because no additional support material is needed. Shade cloth can be installed over the high tunnel plastic or can be installed after the plastic has been removed. For our [low-cost high tunnel \(14 ft. wide x 7 ft. tall x 42 ft. long\)](#) a 20 ft. wide x 48 ft. long shade cloth provides full side and top coverage and allows enough end material for securing the cloth. For high tunnels with an East/West orientation, a 12-foot wide shade cloth, skewed to the south-facing side can be used.

Begin by sliding the shade cloth over the high tunnel and center it from front to back. Similar to the individual rows, the cloth can be positioned to cover the sun-exposed side or, since side access isn't critical, the cloth can be extended all the way down on both sides. Starting at one end, attach the shade cloth to the end walls using 4-foot lengths of lath (Fig. 8). Wrap approximately 6 inches of shade cloth several times around the lath strip and fasten the lath and shade to the door header using 1⁵/₈ inch screws. Next wrap and fasten the cloth to the two side headers (upper and lower).



Figure 7. High tunnel covered with shade cloth after plastic was removed



Figure 8. End of shade cloth wrapped around lath wood and attached to the high tunnel end-wall.

Repeat this process on the opposite end of the tunnel. Pull the shade tightly across the length of the tunnel house. A tightly installed shade cloth reduces flapping and increases the life of the shade cloth.

After attaching the shade to the end frames, use the nylon rope tie downs attached to the bottom of the ribs (Fig. 9). These are tied tightly to keep the shade cloth secured. Use a slip knot to periodically retighten the shade cloth. For USU's low-cost tunnel design, ropes are used to secure the plastic and these are reused for the shade cloth.

Shade Structure Kits

Several companies offer kits that come with all the materials needed to construct a shade structure. Kits are a simple way to make sure all the materials needed are there and can work well. Kits are typically more expensive than the do-it-yourself methods described and do not offer as much customization as self-construction.

Shade Cloth

Before purchasing shade cloth, evaluate the percent light reduction and shade color options. For most fruits and vegetables, 20 to 40% shade is ideal. Cloths with a very low shade percentage (<10%) have a higher risk of tearing under field conditions. Cloths with a high shade percentage (50%+) do not allow adequate light through for healthy plant growth nor do they improve sunburn



Figure 9. Nylon rope tied to rebar supports under PVC high tunnel ribs and pulled tight over shade cloth.

protection. Shade colors include white, green, black or silver. All colors are equally as effective so the lowest cost is the most effective. Once the season is finished, shade cloth should be removed, carefully folded, and stored in a dark, dry place. With proper installation and storage, most knitted shade cloth has a functional life of 7 to 10 years.

Materials and Tools

Individual Row (100 ft. long row)

Materials	# pieces	\$/piece	Total
• 2 ft. long, ½ in. Rebar	22	\$1.97	\$43.34
• ½ in. Conduit (10 ft. lengths)	11 (arches) plus 10 (spanners)	\$3.35	\$70.35
• Cross connector (½ in.)	9 (center arches)	\$0.89	\$ 8.01
• Hoop/perlin connector (½ in.)	2 (end arches)	\$3.00	\$ 6.00
• Shade cloth (30%, unfinished)	6 ft. wide (110 ft. long)	\$0.65	\$71.50
• Snap clamp (3 in. by ½ in.)	3 (per arch) plus 2 (spanners)	\$0.22	\$12.10
	Total:		\$ 211.30

Tools	Price
• Hammer	\$10.00
• ½ in. Conduit bender	\$35.00

Small Field (40 ft. x 40 ft.)

Materials	# pieces	\$/piece	Total
• 10 ft. T-Posts	9	\$10.29	\$92.61
• 1.5 in. PVC endcap	9	\$1.41	\$12.70
• 12.5 gauge wire	160 ft. (perimeter) 104 (anchors)	\$0.10	\$26.40
• Medium Gripple	1	\$1.40	\$1.40
• Wire clips* (every 2 ft.)	72 (18 per side)	\$0.48	\$34.56
• Post attachments	10	\$0.40	\$4.00
• Ground anchors	8	\$5.45	\$43.60
• Shade cloth (30%, finished)	2 (20 ft. x48 ft.)	\$171.90	\$351.80
	Total:		\$567.03

* If using finished shade cloth (with grommets), wire clips are not necessary.

Small Field (Continued)

Tools	Price
• Post pounder	\$30.00
• Come-Along Hand Winch	\$26.00
• Hammer	\$10.00
• Leather gloves	\$8.00
• Safety Glasses	\$2.00

High Tunnel (Tunnel size: 14 ft. wide x 7 ft. tall x 42 ft. long)

Materials	# pieces	\$/piece	Total
• Nylon rope	14 (25 ft. lengths)	\$2.00	\$28.00
• 4 ft. Lath	Bundle of 50	\$15.88	\$15.88
• 1 ⁵ / ₈ in. Screws	1 pound box	\$7.98	\$7.98
• Shade cloth (30% finished)	1 (20'x48')* or (12'x48')	\$171.90	\$171.90
Total:			\$223.76

* For E/W tunnel orientation a 12 ft. x48 ft. (\$125) shade cloth can be used

Tools	Price
• Drill	\$50 - \$150

Suppliers

Many common items (conduit, rebar, and lath, etc.) can be purchased from local box stores. Pricing will vary and costs listed are approximate prices only. Shade cloth and some accessories will need to be purchased from online sources. A list of possible vendors is included below. This list is not exhaustive and USU does not endorse those companies listed.

Fabric Suppliers

AgFabric <https://www.agfabric.com/>

US Netting <https://www.usnetting.com/shade-cloth/>

Gemplers* <http://www.gemplers.com/shade-cloth>

Shade Cloth Store

<http://www.shadeclothstore.com/default.aspx>

*Must call for prices

Structures Suppliers

American Clay Works and Supply* (ACW)

<http://www.acwsupply.com/index.php/downloadable-catalog>

Farmtek.com

<http://www.farmtek.com/farm/supplies/home>

Greenhouse Megastore

<http://www.greenhousemegastore.com/>

Build My Own Greenhouse

<http://www.buildmyowngreenhouse.com>

Circo Inovations Inc. <https://www.circoinnovations.com>

LockJawz <https://www.lockjawz.com/products/>

This project is funded in part by USDA-Risk Management Agency and the Utah Department of Agriculture and Foods Specialty Crops Block Grant (SCBG 161039) under a cooperative agreement. The information reflects the views of the author(s) and not USDA-RMA or UDAF.

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